Spring 2010

# Physics 137B Section 1: Problem Set #1
# Due: 5PM Friday Jan 29 in the appropriate dropbox inside 251 LeConte (the "reading room")

**Suggested Reading for this Week:** This week's problems give you a chance to review what you learned last semester about the hydrogen atom and introduce topics on electron spin, including the Pauli Matrix representation.

- For a review of the solution to the Schrodinger Eq for the hydrogen atom, see Bransden and Joachain (B& J) section 7.5
- The Stern-Gerlach experiment is described in B& J section 1.5
- The final problem on this problem set covers material in B& J sections 6.7 and 6.8. which will be discussed in class on Monday Jan 25.

**Homework Problems:**

1. What is the effective Bohr radius and ground-state energy for each of the following two-particle systems?
   (a) $H^2$. a deuteron and an electron (heavy hydrogen)
   (b) $He^+$, a singly ionized helium atom
   (c) Positronium, a bound positron and electron
   (d) Muonium, a proton and a negative muon ($\mu^-$). The $\mu^-$ has a mass 207 times that of the electron.
   (e) Two neutrons bound together by their gravitational field
2. B& J problem 7.14
3. B& J problem 7.18
4. B& J problem 1.23

5. The matrix representation of the spin operator for spin=$\frac{1}{2}$ can be related to the Pauli spin matrices $\vec{\sigma}$:

$$\vec{S} = \frac{\hbar}{2}\vec{\sigma}$$

Using the explict form of the Pauli matrices (defined in B& J eq 6.243), show the following:

(a) $\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = 1$

(b) The commutators of the components of $S$ satisfy the angular momentum commutator relations $[S_i, S_j] = i\hbar\epsilon ijlS_k$

(c) The Pauli matrices *anticommute*: $\sigma_x\sigma_y + \sigma_y\sigma_x = 0$

(d) Tr$\sigma_i = 0$

(e) det$\sigma_i$ = -1

(f) $\sigma_i$ has eigenvalues $\pm 1$ and thus $S_i$ has eigenvalues $\pm h/2$

(g) $S^2 = \frac{3}{4}\hbar^2 I$ where $I$ is the identity matrix

(h) B& J equation 6.241